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OCEANUS

EDITOR: JAN HAHN

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THE fisherman on our cover and the whalemen on this page are Portuguese. With the tragi-comedy of the Santa Maria fresh in our minds, let us not forget that the Portuguese have been renowned seafarers for over 500 years. Under Henry the Navigator they launched the great age of exploration. Indirectly, as they held the trade route to the East Indies, the Portuguese were responsible for the Dutch and English discoveries in the Arctic in the search for a northeast passage. Azorean and Cape Verdean Portuguese manned the Yankee whalers, while today, as for hundreds of years, a large fleet of Portuguese dory schooners fishes for cod and haddock on the Grand Banks. Indeed, we have always felt that if Columbus had taken the northern route, the Grand Banks fishermen could have told him that a huge land was just to windward "um pouco".

Editorial

VOL. VII, NO. 3, MARCH 1961

"Together let us explore the stars, conquer the deserts, eradicate disease, tap the ocean depths and encourage the arts and commerce."

"We have neglected oceanography, saline water conversion, and the basic research that lies at the root of progress."

THESE words were spoken by President Kennedy in his Inaugural Address and in the State of the Union Message. Probably these were the first occasions of this nature in which a newly-elected President has mentioned our subject. We feel both proud and delighted that President Kennedy did so, and wistfully hope that he may have been influenced, as Senator Kennedy for many years has been on the mailing list of "Oceanus".

The President grew up by the sea and knows boats. Those who love the sea know that she is a demanding mistress who never lets one forget her.

People are beginning to understand the ocean's importance to all. People are beginning to understand the importance of basic research. We must continue to inform them. With a spokesman in the White House the task will be eased.

The 'Crawford' departing in early February. It was quite a winter in Woods Hole.

ALLEN

DEEP CURRENTS IN THE OPEN OCEAN

By Mary Swallow

Deep ocean currents, or eddies, transporting huge water masses were found in 1959 and 1960 during a joint British-U.S. study made off Bermuda.

THE work of the R.V. 'Aries' off Bermuda beween June 1959 and August 1960, measuring deep currents, was a joint project shared by the Woods Hole Oceanographic Institution and the British National Institute of Oceanography. In retrospect it is agreeable to find that more data was collected than seemed possible at a time when, through adverse weather conditions, sickness or the inadequacy of the ship's mechanical and electrical equipment, the 'Aries' was often unable to sail on time and even more frequently unable to spend the twelve days at sea which was required of her. In the event 80 neutrally-buoyant floats were tracked from the research vessels 'Aries', 'Crawford', and 'Atlantis', somewhat more than half of the floats at a depth of 2,000 meters and most of the others at 400 meters and 4,000 meters. The floats moved a total distance of 1,360 miles and were followed for about 400 days (counting a day more than once if more than one float were being followed); well over 500 fixes were made on the floats.

The aim of the project was to measure deep currents in the open ocean away from the continental coasts and any strongly marked surface currents such as the Gulf Stream System. Bermuda seemed, and proved, to be a particularly good base for the 'Aries' which, because of her available fresh water storage, could not stay at sea longer than about two weeks. Water deeper than 4,000 meters was within a few hours' sailing of land, and the Loran system of navigation was usable, particularly to the west of Bermuda where most of the work was done; in tracking

The R.V. 'Aries' off Bermud

the neutrally-buoyant floats it is necessary to know positions as precisely as possible. Since August 1959 the additional use of Loran C gave a much greater accuracy than was hitherto possible. Mr. R. G. Walden developed a receiving set which he installed on the 'Aries' giving an accuracy of position of about 200 yards in the usual working area; she

was thus one of the first ships to use this system of navigation. Both Loran and Loran C became too poor to use to the east of Bermuda.

It had been thought that the deep currents in this part of the open ocean might be very slow moving and the neutrally-buoyant floats made at the National Institute of Oceanography and brought to Bermuda were designed to have a long life of six months. It was found however, quite soon, that currents at both 2,000 meters and 4,000 meters might have velocities as high as 12 centimeters per second* for varying periods, and as the shortest interval between the working area and returning to it was a week, the search on return proved very time-consuming and often unrewarding. At the end of July 1959 each remaining long-life float was converted to two conventional floats, and shorter measurements planned to last for a single cruise were made thereafter.

From June to August 1959 the work was in an area to the west of Bermuda and the floats travelled with considerably varying speeds and directions, but usually with a westerly component.

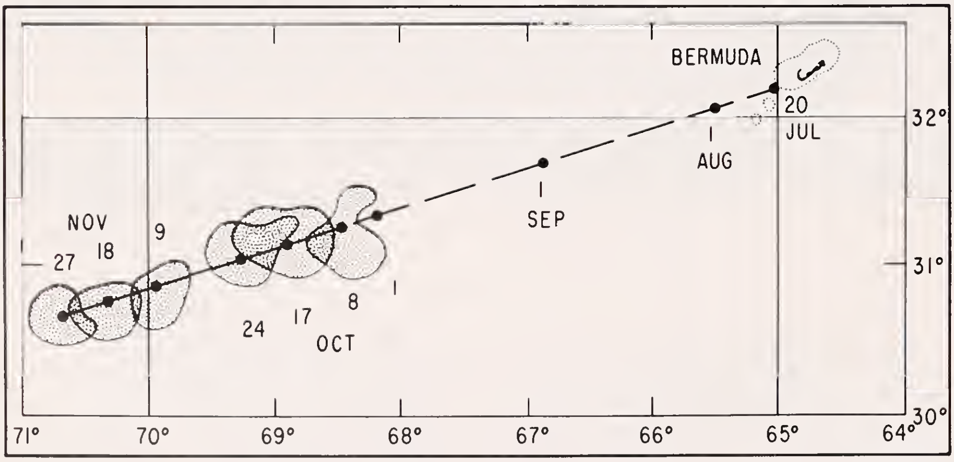
* About ¼ of a knot. 2 centimeters per second (cm/sec) are equal to about one mile per day. One mile per hour is equal to 51.48 cm/sec.

The "cold patch"

An unexpected but interesting development in the project plans was the tracking, from the beginning of October until the end of November 1959, of what was familiarly termed the "cold patch". It was noticed that in an area to the southwest of Bermuda the isotherms* curved towards the surface, and it seemed possible that this might be associated in some way with the strong variable deep currents. Further investigation, using bathythermographs and making hydrographic stations, showed this area to be a lens-shaped thickening of the 18° C. layer travelling as a whole to the southwest. Neutrally-buoyant floats in this lens at 400 meters depth moved quickly, at speeds of about one knot and the tracks indicated that the lens was rotating in a clockwise direction. The currents (4 to 7 centimeters per second) at 2,000 meters and 4,000 meters apparently bore no relation to the position of the cold patch, although the average of these deep velocities was similar to the velocity of the whole patch.

* Lines of equal temperature.

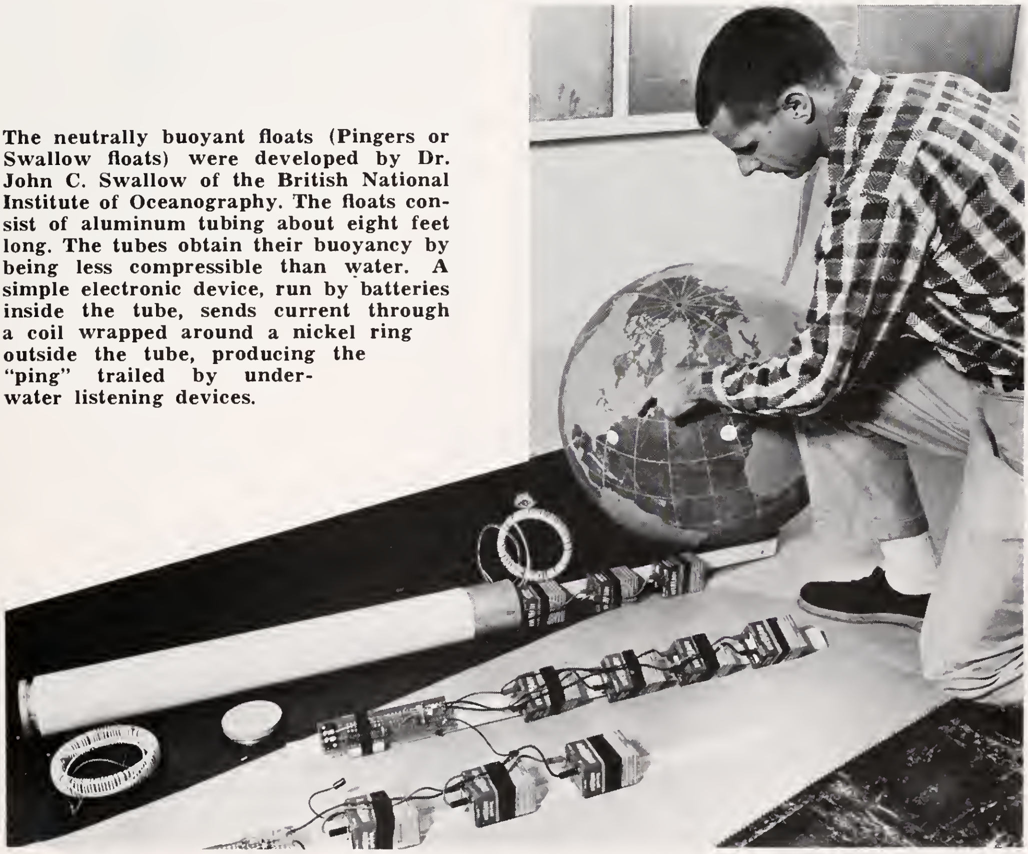
The positions of the "cold patch" in October and November 1959 show where the 66° F. isotherm (which elsewhere lay at a depth of 600 to 700 feet) came within 400 feet of the surface. The patch moved 117 miles in 50 days, a speed of 5.0 cm/sec. (about 1/10th of a knot).



Extrapolating backwards in time it seemed possible that this cold patch had originated near Bermuda, leaving there in July 1959, and was possibly caused by the extra cooling of the shallow waters within the reef in the previous winter. The slightly higher oxygen values in the lens also suggested a local origin and even more strongly so did the presence in the cold patch of spiny lobster larvae most probably from Bermuda. After the 'Aries' was refitted in January 1960 and during the months of February and March when it was difficult, on account of the weather, for the ship to work at sea for more than a day or two at a time, the waters immediately around Bermuda were investigated. Floats were put down at 400 meters and 1,200 meters and those at 400 meters within the 1,000 fathom line showed a weak clockwise rotation of water around the islands. Hydrographic stations, however, showed little, if any, evidence of the formation of a cold patch for the coming autumn. It still remains impossible to tell whether the cold patch had an island origin, or whether it had some totally different cause.

Deep Currents

From April 1960 to August 1960 six visits were made to the area west of Bermuda which had been visited in 1959, in approximately 31° to 32° North and 67° to 68° West, an area of relatively flat sea floor. Deep currents with speeds up to 13 centimeters per second were found. In April 1960 a vertical profile was made with four floats at depths between 2,000 meters and 5,000 meters. The flow was predominantly southward, with a westward component which decreased with depth. On subsequent visits a northwesterly flow was sometimes found, alter-

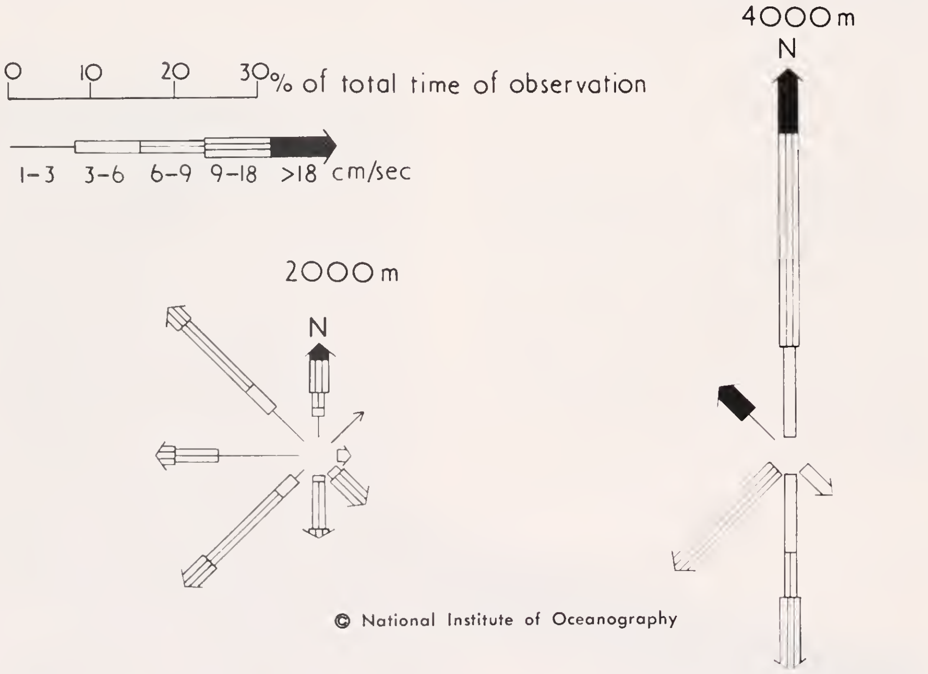


The neutrally buoyant floats (Pingers or Swallow floats) were developed by Dr. John C. Swallow of the British National Institute of Oceanography. The floats consist of aluminum tubing about eight feet long. The tubes obtain their buoyancy by being less compressible than water. A simple electronic device, run by batteries inside the tube, sends current through a coil wrapped around a nickel ring outside the tube, producing the "ping" trailed by underwater listening devices.

nating with southwestward movement at intervals of a few weeks. It was noticed that floats at 4,000 meters depth consistently moved more nearly north or south than did neighbouring ones at 2,000 meters though the angles between their tracks rarely exceeded 30°. In nearly every case the current was faster at 4,000 meters than it was at 2,000 meters.

On several occasions, pairs or groups of floats were put down at the same depth; usually the floats would show similar movements if they were spaced not more than 30 miles apart, though once when a triangle of floats was laid at 2,000 meters depth, 15 miles apart, one of them moved quickly in a clockwise curve at 11 centimeters per second, whilst the other two hardly moved at all.

Two visits were made in the summer of 1960 to the northeast of Bermuda (the distance to the east was limited by the use of the Loran system); one was made at the end of May and the beginning of June as a contribution to the Woods Hole multiple ship Gulf Stream Survey,* when four floats, laid at 3,000 meters depth along a 70-mile line, moved generally southwest; the other was made in July 1960 to an area around 34° North 62° West when a narrow fast-moving streak of deep water was observed. Floats at a depth of 2,000 meters about thirty miles apart moved north at 6 to 8 centimeters per second, but one, halfway between them, moved northwards at 13 centimeters per second, accelerating to 20 centimeters per second.



The arrows shown in these current roses indicate the observed directions of flow of the deep currents, grouped around 8 points of the compass.

The thickness and shading show velocity in cm/sec. (2 cm/sec. = 1 mile per day, approximately). The length of each shaded portion represents the time during which currents in that speed range were observed in that direction, expressed as a percentage of the total time of observation at that depth.

The rose for the currents observed at a depth of 2000 m. is based on 247½ days' observations; 41¼ days (8.6% of total) are not represented as the velocities were weaker that 1 cm/sec., or the directions were erratic. The rose for the currents observed at a depth of 4000 m. is based on 63½ days' observations.

* See Oceanus, Vol. VI, No. 4.

Two floats at 4,000 meters in this central region moved even more rapidly northwards, one travelling at 42 centimeters per second (about four-fifths of a knot), by far the highest velocity observed at such a great depth.

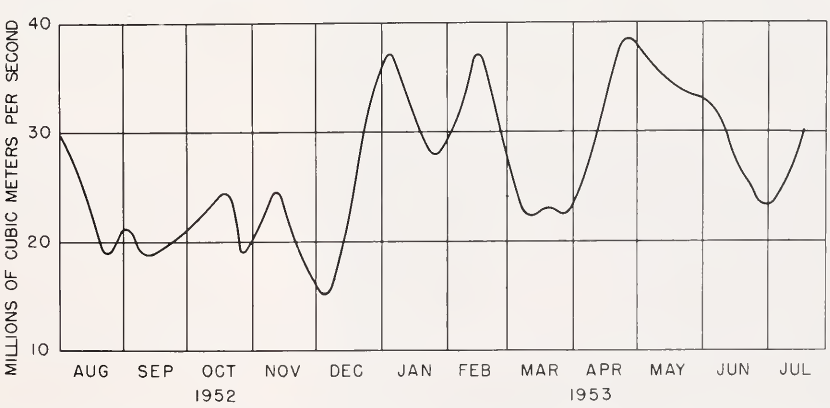
General impression

The general impression is, then, of the deep currents being more rapid and more variable than had been expected, with no evidence for a decrease in speed with depth. In fact, the average speed observed at 2,000 meters depth, regardless of direction, was 6 centimeters per second, whilst at 4,000 meters the average was nearly 12 centimeters per second. From the fragmentary evidence obtained about the length and time scales to be associated with the observed fluctuations of deep currents, it seems as if they may perhaps be regarded as eddies with a typical diameter of about 100 miles, or alternatively as streams with a typical width of about 100 miles, showing large changes of direction at intervals of a few weeks. Although the average speeds of the deep currents may seem fairly slow (12 centimeters per second is not quite a quarter of a knot) these fluctuating streams are broad and deep and are transporting large volumes of water. For example, a typical stream 100 miles wide extending down through the deep water from 2,000 meters to 5,000 meters and moving at an average speed of only 5 centimeters per second would be transporting as much water as the Florida Current.

How these fluctuating currents are generated, and why they are so much stronger in the Western Atlantic than in the East, is not yet clear. Our immediate need is to collate and publish the data.

Acknowledgments

The 'Aries', a 93-ft. ketch, arrived in Woods Hole in March 1959, and was fitted out as a research vessel by June 1959; she was then used continuously on current-measuring until August 1960. Her longest stay ashore was from December 14th, 1959, until February 2nd, 1960, when her engine was replaced by the spare reconditioned one from England. Thus, excluding the refit, she was available to the project for 390 days. About 53% of the total time, 206 days, was spent at sea, 186 days of which were on cruises to deep water, and of this deep-water time 129 days were spent in the selected working area. Captain J. W. Gates was in charge until after the refit when Captain H. H. Seibert took over until the end of the project. Mr. C. L. McCann was mate for the entire period.



The rapidly fluctuating transport in water volume in the Florida Current, between Key West and Cuba, is shown in this diagram of observations made with the Geomagnetic Electrokinetograph.

Changes in transport from 15 to 40 million tons of water per second take place in one month or in even shorter periods.

It was particularly fortunate that, in October and November 1959, the R.V. 'Crawford' (Captain David F. Casiles) was made available for the project to work in conjunction with the 'Aries'; the greater speed and range of the 'Crawford' were undoubted assets. In December the R.V. 'Atlantis' (Captain W. Scott Bray) replaced the 'Crawford' for the last cruise of the project in 1959, and owing to bad weather and a sick seaman the ship did not arrive back in Woods Hole until late on Christmas Day.

The scientists continuously with the project were Dr. John C. Swallow and Mr. James Crease from the National Institute of Oceanography. Mr. Henry Charnock, also from England, Mr. Joseph R. Barrett and Mr. Gordon H. Volkmann, both from Woods Hole Oceanographic Institution, were with the project for lengthy periods in 1959. Mr. Allan Robinson, Mr. Edward D. Stroup, Mr. Robert G. Walden, Mr. Robert Sexton, Mr. John S. Farlow, and Mr. John D. Sandblom, all from the United States of America, sailed on various cruises of the project in 1959. In 1960 Mr. G. M. Cresswell from Stanford University visited the ship for a short period.

Professor Henry M. Stommel, to whom the U. S. National Science Foundation had awarded the money for the project, visited us on a number of occasions and took part in several cruises.

We were greatly helped by the kindness of Dr. W. H. Sutcliffe, the Director of the Bermuda Biological Station, with his unfailing solicitude for the project and his practical help to the personnel. Office space was rented at the Biological Station and the families of the scientists were housed on the property. The 'Aries' used a jetty in St. George's Harbor and the families of some of the marine personnel were housed in the town of St. George.

We feel particularly grateful for the continuous unfailing help from many members of the Institution which made the persistent accumulation of data possible, and we are especially conscious of what we owe to Dr. Fye and Professor Stommel.

The 'Aries' showing her pace

An Interpretation of the Deep Current Measurements

BY C. O'D ISELIN

WHILE Dr. and Mrs. Swallow have wisely refrained from trying to explain the rather unexpected results of the 'Aries' deep current measurements, the following interpretation seems to me a reasonable one. South of Cape Hatteras the depth of the Gulf Stream is limited by the depths over the Blake Plateau, namely about 1,000 meters. If we assume that northeastward from Cape Hatteras, the current gradually increases in depth and in transport, and there is considerable evidence that this is indeed the case, then the additional northeastward moving water must come from the Sargasso Sea. Supposing that as the Gulf Stream passes west of Bermuda it is increasing in depth from about 1500 m. to about 2500 m. Then one would expect that the net flow at 2,000 meters in the area west of Bermuda would be towards the west and this is what the second diagram, summarizing the data shows. Furthermore, if the Gulf Stream continues to deepen in the downstream direction, by the time it reaches a point north of Bermuda perhaps it is beginning to entrain water from the 4,000 meter level. Finally, in part the considerable variations in velocity and direction observed at both levels are no doubt due to eddying motions, as Mrs. Swallow points out, but one must also remember that the Gulf Stream meanders and that its mean track shifts in position, especially after passing the Grand Banks. These variations in position of the Gulf Stream perhaps require deep adjustments within the Sargasso Sea. This would explain also why the deep currents in the west are sometimes so much stronger than any that have been observed off the European coast.

A deep countercurrent in the Gulf Stream area off the Blake Plateau was found during the IGY by the use of the Pinger in another joint National Institute — Woods Hole program. See: Oceanus, vol. V, nos. 3 and 4, and Life Magazine for November, 1960.

MARY SWALLOW is the wife of Dr. John C. Swallow, she has been at the National Institute of Oceanography since 1953 and was librarian until she went to Bermuda in 1959.

Where are the ships?

THE R.V. 'Atlantis' (Capt. A. D. Colburn Jr.) left Woods Hole on January 12th, on cruise #263, to study the formation of Mediterranean bottom water. It is thought that bottom water is formed during the winter months in such areas as the Ligurian Sea off the French and Italian coasts, but the mechanics and extent of production during this process are unknown. The present cruise was planned to lay the foundation for future studies of this problem. Since the entire fluid column (air and water) has to be considered in the formation of cold, dense water, meteorological observations are also being made by chief scientist A. R. Miller and his scientific party consisting of three from Woods Hole, and D. P. Tchernia of the French Laboratoire d'Oceanographie Physique, Dr. H. Charnock of the British National Institute of Oceanography and Dr. Eric Kraus of the Australian Snowy Mountains Authority. The ship will return about April 17th.

The R.V. 'Chain' (Capt. E. H. Hiller) left February 2d on cruises #17. The major portion of the cruise will be devoted to a study of the Romanche Trench. This feature lies on the Equator at about 18° West Longitude and is an interesting region geophysically for a number of reasons. With a depth of greater than 8,000 meters, it is unlike other known ocean deeps in that it is not adjacent to an island chain or continental land mass. Rather, it lies on the Mid-Atlantic Ridge itself. The Trench area generally may represent the saddle point of the Mid-Atlantic Ridge where the deepest communication between the Eastern and Western Basins occurs. In the same general area, though not associated with the presence of the Trench, strong indications were found during the International Geophysical Year of an easterly flowing Equatorial Undercurrent. The ship will return on or about May 15th.

Continued on page 24.

ATLANTIS RECORD

The 'Atlantis' hove-to, rolling in a long swell.

(FROM A KODACHROME BY F. C. RICHARDS).

ON November 30th, 1960, the research vessel 'Atlantis', on her 261st cruise, reached a milestone in her long career. Capt. Arthur D. Colburn and L. Valentine Worthington, Chief Scientist, radioed the news from the mid-Atlantic:

"ATLANTIS' 5000TH STATION COMPLETED TODAY IN LATITUDE 18° 30′ NORTH, LONGITUDE 55° 51′ WEST."

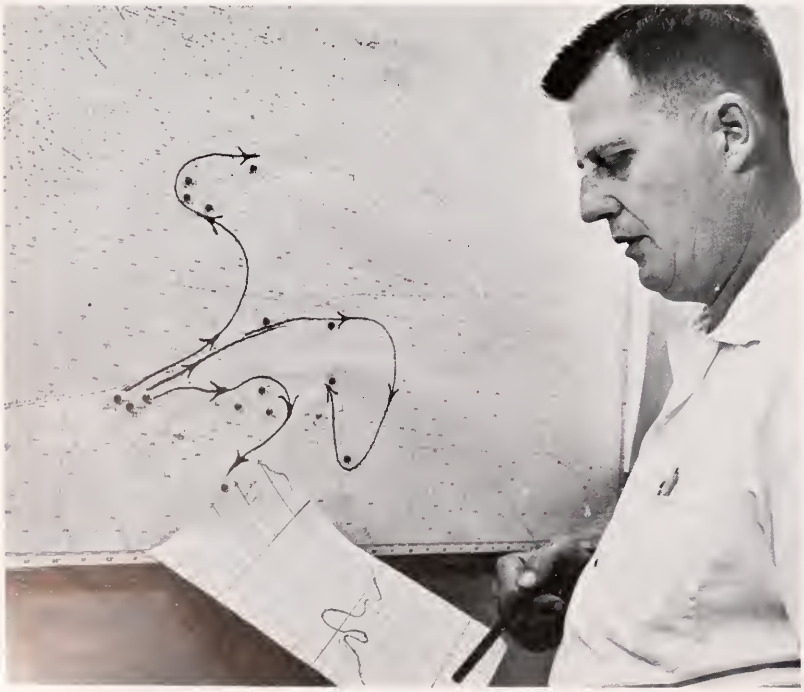
Dr. Paul M. Fye, Director of the Institution, sent congratulations in return.

A hydrographic station is one of the basic operations in oceanography. To make a station, a series of Nansen bottles with attached thermometers are lowered into the ocean to obtain temperatures and water samples at various depths from surface to bottom. Completing a station takes several hours depending upon the depth to be sampled. Usually two "casts" are made. One above 2000 meters with closely-spaced bottles, and one from 2000 meters to the bottom with more widely-spaced bottles.

The 'Atlantis' is believed to be the only research vessel to reach the 5,000 mark. A 142-foot steel-hulled ketch, she was built for the Institution in Denmark in 1931 and, except for a short lay-up during the worst war years, has been continuously in use. She has traveled about a million and a half miles since her first station was made on July 26, 1931, on the initial crossing from Europe. On that occasion the position was 52° 28′ North, 29° 46′ West and Dr. Columbus O'D. Iselin was both master and chief scientist. Dr. Iselin is Henry Bryant Bigelow Oceanographer at the Institution and served formerly as its Director.

The 5,000th station (numbered 6,000. The first station started as A-1000.) was made during a cruise to locate and make measurements in the area of salinity maximum in the North Atlantic.

Gulf Stream Meanderings



A. R. Miller with a chart showing the initial paths of the three radio transponding buoys set within a circle of 15 miles during the multiple ship survey "Gulf Stream '60". In his hands Mr. Miller has a chart indicating the wide meanders of the Gulf Stream System in the same area during the Spring months of 1960.

—40°

—35°

—30°

25°

THAT complex Gulf Stream! The more we look at it, the more difficult it is to understand. During our multiple ship study, Gulf Stream 1960, (see Oceanus, Vol. VI, No. 4) six of Mr. D. Frantz' radio drift buoys were set out. Two, called Tango and November were never heard nor seen again; one (Alpha) was inadvertently picked up by a Radar Picket ship after 11 days.

Of the remaining three buoys, all set within a 15 mile circle, Hotel (2) drifted generally in a "classic" Gulf Stream direction, although it could not make up its mind going around in circles for about a month along 60° West and after 117 days, near the end of its life span, seemed determined to home again. India (3) launched on May 13 at almost the identical launching site of Hotel (2) drifted in circles until lost on June 15th. Mike (4) proved itself, to the surprise of Mr. Frantz and everyone else, Mike's sender and receiver kept operating for 199 days, while Mike placidly travelled to Bermuda, hesitating in a circle only once, and staying for seven days close to Bermuda before travelling back to the Gulf Stream off South Carolina. Two days before Christmas, Hotel was still working and located by Mr. Frantz in our R4D airplane. On January 6, 1961*, the long lived veteran did not respond to our calls.

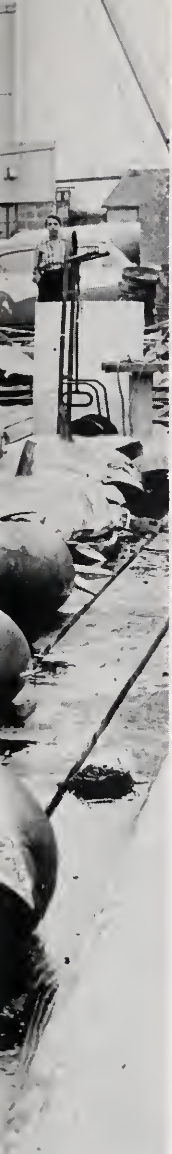
What these meanderings mean in terms of our knowledge of the Gulf Stream System has not yet been analyzed. At any rate the buoy operation represents the first time that we have been able to continue the study of a major ocean area for so long a period.

The six buoys were manufactured by Prodelin, Inc. from our basic old design. The radio receivers had a life span of six months, (Hotel gave out after six months and two weeks!) while the senders could be triggered on demand for a life span of 12 to 1500 transmissions of 15 seconds duration.

Since our R4D does not have the necessary range, the locating of the radio-transponding buoys was largely due to the cooperation of the U.S. Navy Air Development Unit of South Weymouth, Mass. For future studies it is hoped that the Institution will be able to acquire an R5D (DC-4) capable of long overwater flights.

Mr. Mather, in the background, and his assistants Dorothy Rogers (standing) and Margaret Watson (kneeling) inspect some of the bluefin tuna brought to Woods Hole for further studies (and some eating).

Excellent catches of bluefin tuna in the northwestern Atlantic were made in November on the 1,000 fathom line, thus closing a gap in our knowledge of the yearly distribution cycle of this fish.



Closing a Gap

in Our Knowledge

By FRANK J. MATHER III

ALTHOUGH it is one of our most important offshore gamefish, and also of interest to commercial fishermen, much of the migratory cycle of the western Atlantic bluefin tuna remains a mystery. Thirty years ago, this fish was known only through its appearance in northern coastal waters in the late spring, summer and early fall. In the 1930's, sportfishermen discovered a regular northward run of giant bluefin in May and early June in the Bimini-Cat Cay area of the Bahamas. In the last few years, the U.S. Fish and Wildlife Service has conducted extensive exploratory tuna fishing programs in the northwestern Atlantic and also in the Gulf of Mexico and parts of the Caribbean Sea. Fishing with Japanese long line showed that giant bluefin were present in the Gulf of Mexico and in parts of the northern Caribbean in the winter and through much of the spring, and others, mostly of medium size, occurred in these seasons in the northwestern Atlantic, mostly between Georges and the Nova Scotia Banks and the Gulf Stream. The almost complete failure to catch any of these fish in the deep oceanic or southern waters during the summer and early fall indicated that in these seasons most of the population must be on the Continental Shelf, including the coastal waters from Cape Hatteras to Newfoundland and the outer banks. No exploratory fishing had been done in the northwestern Atlantic in November or December, and the Gulf and Caribbean program had not produced any bluefin in these months. Also, our extensive studies of the inshore sport and commercial fisheries had revealed few traces of the bluefin, which usually disappear from northern coastal waters in October or early November.

Cruise 56 of the R/V 'Crawford' in November was designed to fill this gap in our knowledge of the bluefin tuna, and also to contribute toward the completion of the year's cycle of exploration of the northwestern Atlantic. Fishing for tuna and other large oceanic fishes was carried out with Japanese long line gear loaned by the U. S. Bureau of Commercial Fisheries, which also furnished most of the herring used as bait. This line, up to seven miles long, was suspended from floats so that the hooks, up to 500 in number, fished at depths of from 15 to 60 fathoms or more. The scientific fishermen who had been preparing and baiting the gear since about 4:30 A.M., usually started setting it over the stern at dawn and completed this task in time for an 8 o'clock breakfast. Unless the floats indicated exceptional activity, we allowed the line to fish until mid-morning, when hauling in began with the aid of a special hauler mounted near the bow. This was completed between 1:00 and 3:00 or 4:00 p.m., depending on the amount of line set, the weather conditions, and the catch. All lively tunas were tagged to study their migrations. When hauling was completed, it was time to measure and dissect the catch, and to straighten out the gear for the next day's fishing, a chore which sometimes took several hours.

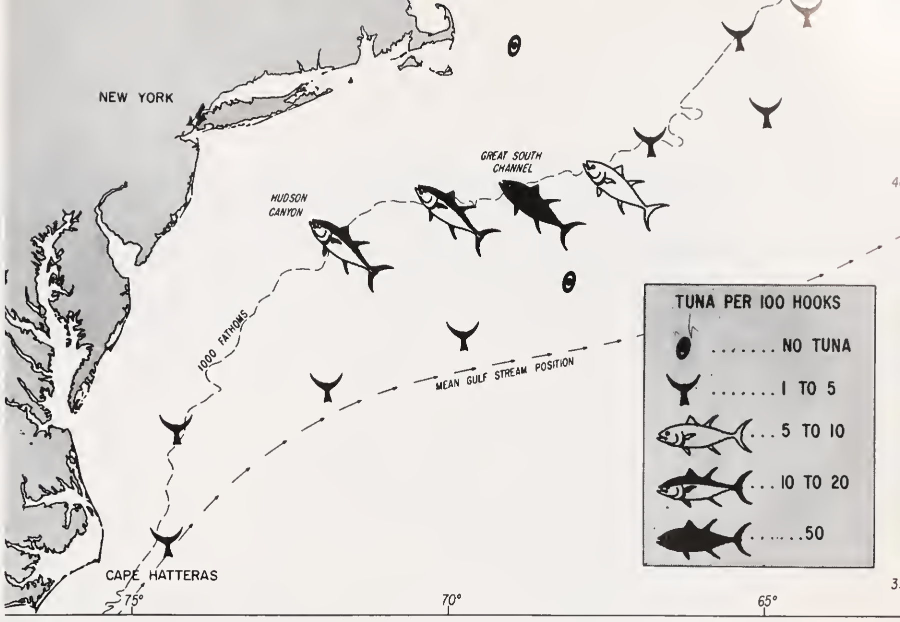
To study the environmental conditions, the party measured surface and subsurface temperatures and salinities, as well as the water transparency. A Woods Hole precision graphic recorder was used to study subsurface scattering layers, and also, on occasion, showed interesting traces of fish being brought in on the line and swimming away after they had been tagged.

For once, results were not long in coming. The 'Crawford' left the Institution dock late on Veteran's Day afternoon. Within less than 24 hours, her foredeck was loaded with bluefin tuna, as well as three true albacore and a bigeye tuna. This catch, totalling 57 tunas, of which 17 were tagged, on a modest set of 310 hooks was made only 125 miles southeast of New York City, on the 1,000 fathom curve at the entrance of Hudson Canyon. This was a surprise, as previous fishing in this area by the M/V 'Delaware', of the

RASCOVICH

Setting a Japanese long line. Each basket contains about 800 feet of line with one hundred hooks set about 100 feet apart. A total of seven miles of line was set out on various occasions during the experimental fishing.

The distribution of bluefin tuna as found during the November cruise of the R.V. 'Crawford'. As commercial fishermen find it economically practical to obtain six fish per hundred hooks, the catches on the 1,000 fathom line were remarkable.



U. S. Bureau of Commercial Fisheries, in other seasons was unproductive, and there had been many indications that the bluefin tuna travelled more to the eastward when they left the coastal waters.

Working southward, we made a set at the entrance to Norfolk Canyon off Chesapeake Bay, and another in the Gulf Stream off Cape Hatteras. These produced only three and four tuna, respectively, indicating that the concentration off New York did not extend so far southward. Two sets to the northeastward, well outside the 1,000 fathom curve, but north of the Gulf Stream, yielded only one and five albacore, respectively. These results dictated a return to the 1,000 fathom line, where the next set was made at the entrance of Hydrographer Canyon, at the opening of Great South Channel. As the weather was very rough, only 320 hooks were set, but the catch of more than 185 fish was the largest ever made in deep water northwestern Atlantic exploratory fishing. Over 100 bluefin were tagged and released, 60 were boated, and at least 25 more were lost alongside. Only five of the 320 baits were recovered. As this confirmed the concentration along the edge of the shelf, and no bluefin had been taken further offshore, the question arose as to whether they had all left the inshore grounds. Therefore, a small set was made 50 miles east of Pollock Rip, at a well-known tuna ground, called "Tobins" by the commercial fishermen. This produced no bluefin, but revealed an unusual concentration of small mackerel sharks. Subsequently, we have received reports of giant bluefin observations in late November and early December off western Long Island and northern New Jersey.

Up to this point the weather had been favorable — it had been possible, although sometimes very difficult, to fish every day. Then two days were lost due to a storm, and the vessel was driven from the planned position. Finally an offshore set was made just north of the Gulf Stream, near where, in May, 1959, the 'Delaware' had made her best catches of bluefin. The catch on 330 hooks consisted of a single blue shark. Returning to the 1,000 fathom line, we fished off the southeastern corner of Georges Bank and in the Eastern Channel between Georges Bank and the Nova Scotia Banks. Both sets produced small catches of bluefin tuna. The former also yielded a bigeye tuna and 31 blue sharks, while at the latter location one large

swordfish, 10 big mackerel sharks and 20 lancet fish were taken. The catch in the Eastern Channel was disappointing, as there had been many indications that this was a migration route of the bluefin, and surface signs, including multitudes of working birds and some surface tuna schools, were favorable.

Dirty weather

On Thanksgiving Day, the weather took over again. A set planned for the southern edge of the Nova Scotia Banks was finally made, but with only 170 hooks, a very short fishing time, and further offshore than had been intended. The catch consisted of a single bluefin, although a school of them was seen on the surface. Another offshore set further south yielded one bluefin and two albacore.

As the time allotted was drawing to a close, the last two stations were planned to confirm and define the concentration along the 1,000 fathom curve. The first, made at the entrance of Lydonia Canyon, about 80 miles east of the scene of the big catch at Hydrographer, produced 30 bluefin, as well as 10 albacore, three bigeye tuna, a very small swordfish, three sharks, an opah and a lancet fish. The last set, due south of Woods Hole, yielded 70 bluefin and an albacore.

Sometimes the results of exploratory fishing are negative, and in many other cases they are inconclusive, being subject to various interpretations. This was one of the fortunate exceptions in which the results were clear cut. As the diagram of the catches shows, all the heavy bluefin catches were grouped along the 1,000 fathom curve between Hudson and Lydonia Canyons. Bluefin were also present off Norfolk Canyon and east and north of the area of concentration, but much fewer in number. None were taken in three sets made offshore and to the south of the heaviest concentration, nor at one made inshore and north of it. Albacore were more extensively, but much more thinly distributed. Bigeye tuna were found in even lesser numbers along the 1,000 fathom curve. The latter two species which are often encountered in the deep offshore waters are but rarely taken by sportfishermen. Although sharks were taken at most of the stations, only two of the 385 tuna caught were mutilated.

It seems probable that the bluefin tuna were schooling in preparation

ARENDS

Tagging the lively tuna led to a few acrobatics on the 'Crawford'.

RASCOVICH

The fearsome aspect of a lancet fish. Widely distributed in the deep waters of the Atlantic, this fish rarely strays inshore.

to moving to their wintering grounds. There was some indication that different fish were passing through the area of concentration. The first two heavy catches consisted of fish weighing from 100 to 300 pounds, with most of them in the heavier part of this range. At the last two sets, there were fewer fish in this size range, and several fish were in the 25 to 80 pound classes. Unfortunately, no giant bluefin were taken, but this cruise has filled an important gap in our knowledge of the life cycle of this swift and elusive tuna. As over 200 tuna were tagged, it is hoped that more information will be forthcoming.

Hauling the long line during a bit of weather

RASCOVICH

MR. MATHER is Research Associate in Oceanography. For many years he has followed large pelagic fishes in his continuing quest to study their natural history.

The work explained by Mr. Mather in this article provides an interesting example how a major effort can be realized at relatively small expense, divided among several groups. The boat time of the R/V 'Crawford' was paid for under a grant for biological ships' time from the National Science Foundation. The Woods Hole Associates' contributions paid for the fishing personnel, while the U.S. Fish and Wildlife Service provided the fishing gear and bait.

Dolphins (Stenella) at the bow of the R.V. Atlantis.

Submariners aid Porpoise Studies

SINCE Woodcock reported his observations on "wave-riding" porpoises in 1948, several explanations have been offered of the phenomenon of porpoises dwelling almost motionless near the bow of ships under way. In all of these explanations it is assumed that the porpoise derives its thrust from the forward sloping surface of the wave attached to the bow of the vessel. It is conjectured that the porpoise is either sliding downwards on this slope under the influence of gravity or that it submerges its tail flukes in the forward facing portion of the wave while the main portion of its body is in the horizontal water ahead of the bow. There are on record, however, observations of porpoises riding at the bow of small and relatively slow vessels that do not generate conspicuous bow waves. Therefore, it was felt by Drs. A. Fejer and R. H. Backus of our staff that the explanations offered are lacking in completeness. A paper containing the results of their findings has been published in "Nature", Vol. 188, No. 4752, pp. 700-703. Drs. Fejer and Backus proposed that the porpoise derives its propulsive power from the pressure gradient that exists ahead of the bow and their calculations indicated that the force on the porpoise, due to the pressure field is of sufficient magnitude to balance the hydrodynamic resistance of the animal.

In view of the fact that submarines traveling submerged do not cause significant disturbances on the surface, observations relating to porpoises near the bows of submarines are of great relevance to these investigations. The bulbous bow type submarine is, of course, of special interest, because of the more extensive high pressure that is characteristic of these shapes. At the suggestion of Mr. A. Vine of the Institution a questionnaire was sent out to the Atlantic submarine fleet through the courtesy of the Commander of Submarine Forces, U. S. Atlantic Fleet. Dozens of submarine commanders returned the questionnaire with an astounding enthusiasm, many of them enlarging considerably upon the questions asked, and providing a wealth of information not only on the swimming behavior of porpoises but also on sound production of the mammals, the "operating depths" of porpoises, and a wealth of other natural history information. The CO of the U.S.S. 'Seacat' even included a photograph of porpoises taken through the periscope. Other officers and crew members also became interested and we understand that many wardroom discussions took place.

Submariners and oceanographers learned to know each other well during and since World War II. The Institution still retains a letter from a submarine commander, written near the end of the war, in which he announced that he would goldplate a bathythermograph, hang it above his bed and pat it every night before going to sleep. It appears now that the submariners are full of enthusiasm to aid us in strictly scientific observations. In the last issue of "Oceanus" we referred to the plankton sampling done for us by the U.S.S. 'Sea Dragon' under the Arctic ice pack. The prompt replies to the porpoise questionnaire undoubtedly are of great value in our understanding of the attractive animals.

Further reading

Bibliography for those who wish to read more about the bow-riding porpoises: Woodcock, A. H., "Nature". 161, 602 (1948); Woodcock, A. H., and McBride, A. T., "J. Exp. Biol.", 28, 215 (1951); Hayes, W. D., "Nature", 172, 1060 (1953); Scholander, P. F., "Science", 130, 1658 (1959); Scholander, P. F., "Science", 129, 1085 (1959); Caldwell, D. K., and Fields, H. M., "J. Mamm.", 40, 454 (1959).

Forecasting New England winters

By J. Chase

"Certis rebus certa signa praecurrunt"

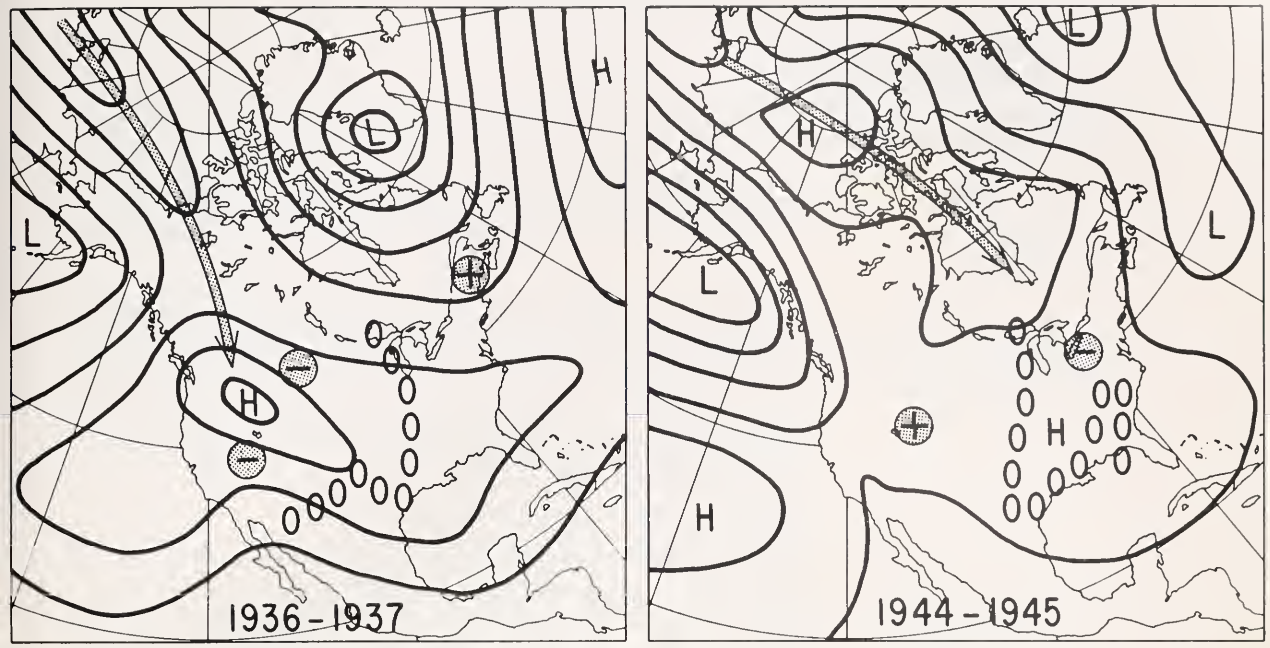
DID Cicero mean this to apply to weather? Or how about Thomas Campbell's more familiar "—coming events cast their shadows before."?

People have been trying for years to forecast the weather at ever longer range by means of "shadows before" such as the length of the bands of the woolly bear caterpillar or networks of isobars derived with clever mathematical formulae and mystical manipulations of digital computers, or try a groundhog, if you will.

A good forecast (by whatever method) of winter conditions not only would give the forecaster a great feeling of well-being but could mean a lot to the operator of a ski resort, or to the oil man who would like to stockpile oil ahead of need in the right parts of the country.

A paper by Dr. Franz Bauer of Frankfurt which noted some interesting associations of November pressures at certain stations and winter temperatures in southern New England has led me to an examination of November pressures in the northern hemisphere and winter temperatures in the United States.

I have found that the pressure distribution of November very often is similar to that of the following winter, which in turn indicates the flow of Arctic air. Although some difficulties remain in the analysis it appears that the ridge of high pressure which normally connects Siberia and the U.S.A. in November is of primary importance. Most of our coldest winter air comes by way of this ridge.



Two simple cases are illustrated. In November 1936 the trans-Arctic ridge entered the States well to the west of its normal position (arrow). In the ensuing winter the area west of the line of zeros had colder than normal temperatures, while the east was above normal. But in 1944-1945 after a November ridge which was well to the east of its normal position, the winter conditions reversed and the east received most of the cold air. This simple scheme works well for the winters of this century, when the trans-Arctic ridge was out of its normal position but, of course, often times the ridge has not shown such a definite dislocation. Means of forecasting these borderline cases are being studied now. We were able to forecast a warm winter for New England for 1959-60 without much hesitation and so it occurred. This year's map, however, gave us trouble right from the start as the ridge had not a definite dislocation and the best we have been able to do so far is philosophize:

> Prudens fururi temporis exitum
> Caliginosa nocte premit deus

Maybe Horace was right!

Certain signs precede certain events.
Cicero.

A wise god shrouds the future in obscure darkness. —Horace.

MR. CHASE is Research Associate in Meteorology on our staff. His ingenuity in applying meteorological knowledge to oceanic problems led him to predicting haddock populations in relation to prevailing winds during the critical larval stage.

Associates' News

Annual Dinner re-scheduled

Not even Mr. Chase could have made a long range prediction for the Annual Associates' Dinner which was to take place on February 8th. The heavy snow in Manhattan made it advisable to re-schedule the meeting for early May.

The noted Swiss scientist, Jacques Piccard who was to be the guest speaker, promises to come to the Dinner, as originally planned, and will share with the Associates accounts of his venturesome dives in the Bathyscaphe.

OUR sympathy to Ronnie Veeder —
His Dinners seem a weather-breeder —
Two years ago a night too warm
And threatened by a thunderstorm,
Last year a record fall of snow,
And this year — well, one couldn't know
And it would hardly be a lark
To get marooned in Central Park.
Oh, speakers, guests and ye who cater,
Expect the Woods Hole Dinner later,
And hope by all your lucky stars
For favorable isobars!

Mr. & Mrs. Henry A. Morss, Jr.

A Splendid Gift

THE EUGENIE VIII, a 59-foot sport fisherman has been given to the Institution by Louis E. Marron, Chairman of the Board of the Coastal Oil Co., and a member of the Industrial Committee of the Woods Hole Oceanographic Associates.

The EUGENIE VIII, designed to aid sea studies, will be used primarily for an expanded program of research and fisheries, such as the natural history studies of pelagic fishes conducted by F. J. Mather III.

Mr. Marron and his wife — after whom the boat is named — hold several world records for the larger game fish. They have shown their interest in research by supporting and taking part in research with the Institution, with the Massachusetts Institute of Technology, and with the Marine Laboratory of the University of Miami.

Where Are the Ships?

The R.V. 'Crawford' (Capt. D. F. Casiles) left on February 7th on cruise #61 to study the area of Maximum Salinity in 28° North, 50° West. The observation program consists of hydrographic stations, current measurements with Swallow floats and transponding drift buoys. A toroidal buoy will also be anchored in deep water. Mr. L. V. Worthington is chief scientist of a party of four. The ship will return about April 4th.

The R.V. 'Bear' (Capt. E. Mysona) is on a three months cruise in the frigid waters of the Gulf of Maine to aid a U.S. Navy evaluation study.

Associates

of the

Woods Hole Oceanographic Institution

(A private, non-profit, research organization)

THE ASSOCIATES of the Woods Hole Oceanographic Institution are a group of individuals, corporations and other organizations who, because of their love for the sea and interest in science and education, support and encourage the research and related activities of the Institution.

Membership dues in the Associates are as follows:

Member	$50
Contributing Member	$100
Patron	$500
Life Member	$1,000
Corporate Member	$1,000
Sustaining Corporate Member	$5,000 or more.

All contributions and dues are tax deductible to the extent provided by law.

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